REMARKS

The Examiner is thanked for the thorough examination of the present application, and for correctly indicating the allowability of the subject matter of Claims 12-13, 21-22, 30-31, and 39-40. Claims 16-19, 25-28, 34-37, and 41-44 have been cancelled without prejudice to Applicant's right to file a divisional application directed to the subject matter thereof.

In view of the arguments presented in detail below, it is submitted that all of the claims are patentable.

I. The Claimed Invention

The present invention is directed to a solid state image sensor. As discussed in the background of the present application, a significant problem that is encountered with typical prior art image sensors is vignetting. Vignetting is the loss of sensitivity in an image sensor due to the shifting of a focusing spot of light collected by microlenses which are offset from the central optical axis of the image sensor.

One prior art approach for addressing vignetting set forth in U.S. Patent No. 5,610,390 is discussed at page 3, line 26 through page 4, line 6 of the background. In this patent, the position of a microlens relative to its corresponding pixel is adjusted by an amount which varies with the distance of the pixel from the optical axis of the sensor array. The optical axis of each microlens is displaced towards the central axis of the sensor array by an amount which is proportional to the distance between the pixel and the central axis. As described on page 4,

lines 2-6, the optical axis of each microlens is displaced towards the central axis of the sensor array by an amount which is proportional to the distance between the pixel and the central axis. This is equivalent to a "continuous" adjustment of the microlenses, and since microlenses are discrete elements, this displacement in practice can be considered as being "step-wise." The background further discusses some problems with this approach at page 4, lines 16-19. In particular, such a fine adjustment of microlens spacing is difficult to implement, and requires a customized array for each different system.

The present invention is directed to a solid state image sensor which reduces vignetting while mitigating such drawbacks associated with the prior art. As recited in independent Claim 11, for example, the sensor includes an array of pixels and a corresponding array of microlenses disposed adjacent the array of pixels. Positions of the microlenses relative to corresponding pixels vary based upon distances of the corresponding pixels from a central optical axis of the solid state image sensor to substantially eliminate vignetting of light collected by the microlenses. Moreover, the array of microlenses is divided into blocks each comprising a plurality of the microlenses, and within at least one of the blocks the positions of the microlenses relative to the corresponding pixels thereof are varied by an equal amount.

Independent Claim 20 is directed to an imaging system, and independent Claim 29 is directed to a camera, both of which include a solid state image sensor similar to that recited in

Claim 11. Moreover, independent Claim 38 is directed to a related method for substantially eliminating vignetting in light collected by microlenses disposed adjacent an array of pixels in a solid state image sensor. Each of these claims recites similarly to Claim 11 that the array of microlenses is divided into blocks each comprising a plurality of the microlenses, and within at least one of the blocks the positions of the microlenses relative to the corresponding pixels thereof are varied by an equal amount.

As described on page 8, lines 31-33 of the originally filed specification, it is desirable for a single sensor to work with as large a range of primary lenses as possible, i.e., with lenses that have as wide a range of primary focal lengths as possible. As mentioned on page 9, lines 2-3, in accordance with the present invention is has been determined that the focused light spot does not need to fall in the center of the sensitive area to achieve the goal of avoiding vignetting. Thus, instead of customizing the displacement of each individual microlens continuously or step-wise throughout the array as in the prior art, in accordance with the present invention an array of microlenses is divided into blocks each comprising a plurality of microlenses, and within at least one of the blocks the positions of the microlenses relative to the corresponding pixels thereof are varied by an equal amount. As a result, variations in the parameters of the microlens array can be applied to blocks of microlenses, rather than to individual microlenses (see, e.g., page 12, lines 18 - 25 of the specification). This advantageously

allows shifting of the microlenses to be accomplished without modification of standard design or manufacturing technologies (see, e.g., page 13, lines 19-28).

II. The Claims Are Patentable

The Examiner rejected independent Claims 11, 29, and 38 based upon Kato (U.S. Patent No. 5,682,203), and independent Claim 20 was rejected based upon Kato in view of Brown (U.S. Patent No. 6,373,633). Kato is directed to a solid-state image sensing device including a plurality of photo cells on a substrate and a plurality of micro-condenser members each on a corresponding photo cell. The interval at which the micro-condenser members are arranged at a central portion of the substrate differs from the interval at which the micro-condenser members are arranged at a peripheral portion. Further, a center of the micro-condenser member and a center of the photo cell may coincide with each other at the central portion of the substrate and may shift from each other at the peripheral portion thereof. Also, a power of the micro-condenser members arranged at the central portion of the substrate may differ from a power of the micro-condenser members arranged at the peripheral portion thereof. Brown is directed to an irradiation profile shaping system which the Examiner contends teaches blocks of tessellated microlenses.

The Examiner contends that Kato teaches an array of microlenses that is divided into blocks each comprising a plurality of the microlenses, and that within at least one of the

blocks the positions of the microlenses relative to the corresponding pixels thereof are varied by an equal amount as recited in the above-noted independent claims. As support, the Examiner points to FIG. 1 and col. 3, line 8 through col. 4, line 2 of Kato. It is respectfully submitted that the Examiner mischaracterizes Kato. In particular, Kato teaches that both the arrays of the microlenses and the pixels include a central portion and a peripheral portion. In column 3, lines 3-7 it is stated that the interval at which the micro-condenser members (i.e. microlenses) are arranged at a central portion of the substrate differs from the interval at which the micro-condenser members are arranged at a peripheral portion. Further, it is indicated at lines 55-59 that the center of each of the photocells that is located at the peripheral portion of the substrate shifts with respect to the center of the micro-condenser provided thereon.

Kato nowhere attempts to provide a definition of "central" or "peripheral" such as by indicating what quantitative proportion of an array could be considered as being "central." Yet, at col. 5, lines 5-8 Kato states that the interval **MH** (i.e., the spacing between microlenses) in a longitudinal array direction (**1C**) varies continuously or stepwise between the central area **1A** and the peripheral area **1B** of the substrate **1**. As such, the image sensor discussed in Kato is similar to that discussed above in U.S. Patent No. 5,610,390. The continuous or step-wise variation in the interval **MH** results in an image sensor that has the same problems as those which are overcome by the

present invention.

In sharp contrast, instead of having a continuous source step-wise variation in the distance, the above-noted independent claims recite that within at least one block of microlenses the positions of the microlenses relative to the corresponding pixels thereof are varied by an equal amount. As mentioned on page 12, lines 23-29 of the originally filed specification, the variation in the parameters of the microlenses being applied to blocks of microlenses rather to individual microlenses may allow shifting of the microlenses to be accomplished without modification of standard design or manufacturing technologies. Thus, the present invention may advantageously be applied at the design stage without having to modify manufacturing processes and is relatively easily implemented for high volume production.

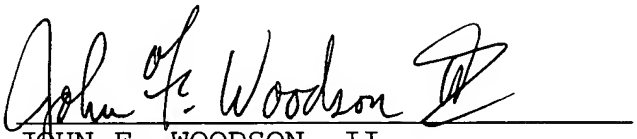
Accordingly, since none of the remaining prior art of record teaches or fairly suggests the above-noted deficiencies, it is submitted that independent Claims 11, 20, 29, and 38 are patentable over the prior art. Their respective dependent claims, which recite yet further distinguishing features, are also patentable over the prior art and require no further discussion herein.

CONCLUSIONS

In view of the foregoing, it is submitted that all of the claims are patentable. Accordingly, a Notice of Allowance is respectfully requested in due course. Should any minor

informalities need to be addressed, the Examiner is encouraged to contact the undersigned attorney at the telephone number listed below.

Respectfully submitted,



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